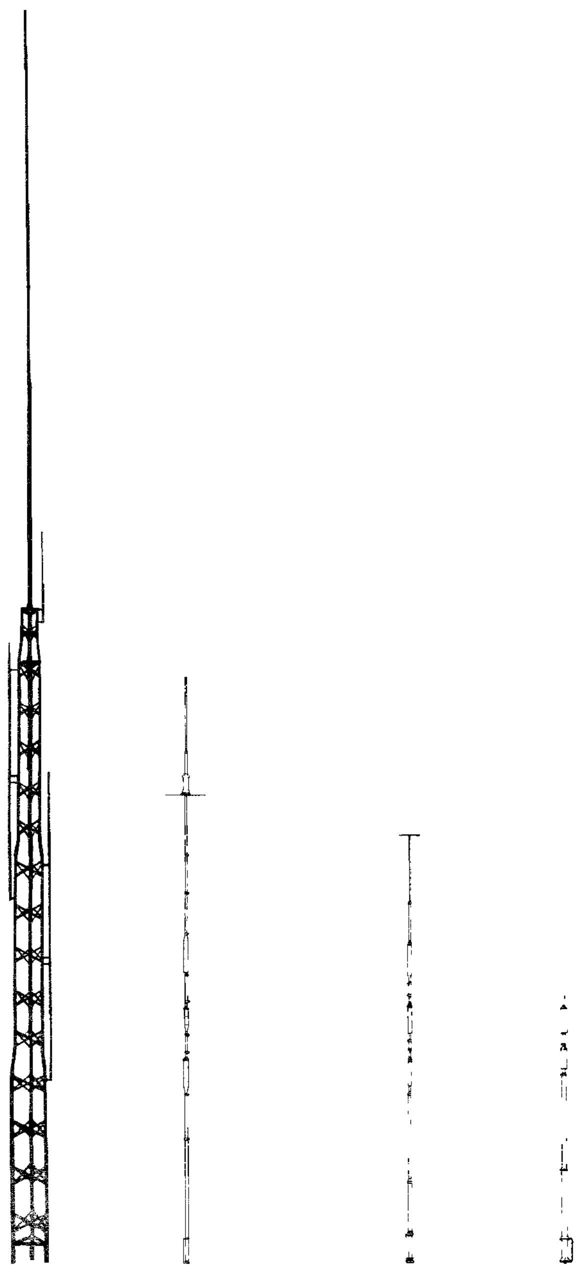
TELEX. hy-gain.
TELEX COMMUNICATIONS, INC.
9600 ALDRICH AVE. SO., MINNEAPOLIS, MN 55420 U.S.A.
Telephone 612-884-4051, telex 29-7053

AMATEUR PHASING

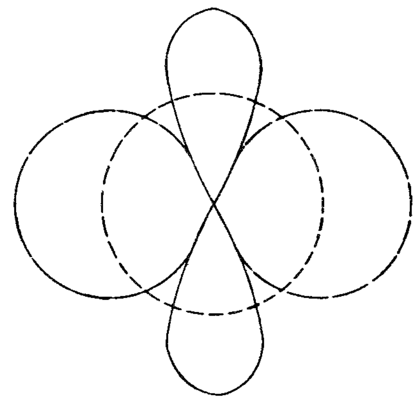
ENGINEERING REPORT

PHASED MULTI-BAND

VERTICALS for ADDITIONAL GAIN and LOW ANGLE RADIATION



18HT-S 18AVT/WB-S 14AVQ/WB-S 12AVQ-S



Phased Patterns

INTRODUCTION

The following Telex /Hy-Gain verticals are well adapted for the phasing arrangements shown in this report.

MODEL 18HT-S HY-TOWER

The 18HT-S is a multi-band vertical antenna with automatic band selection of 10-80 meters by means of a unique stub decoupling system. The Hy-Tower with a base loading coil operates efficiently on 160 meters. The system is foolproof, fed directly with a single 50 ohm coax. No guys are required for the 24 feet high, self-supporting tower. The top mast extends the height to 50 feet. Two units make an ideal phased array.

MODEL 18AVT/WB-S VERTICAL

The 18AVT/WB-S is a multi-band trap vertical for 10 through 80 meters. It is completely factory pre-tuned and exhibits an extremely low angle DX radiation pattern. It is easy to assemble, light weight which one man can install. A single 50 ohm coaxial feedline is required. Two or three 18AVT/WB-S's make an excellent phased array.

MODEL 14AVQ/WB-S VERTICAL

The 14AVQ/WB-S is a self supporting multi-band trap vertical for 10 through 40 meters and is completely factory pre-tuned. It is the world's most popular ham antenna with an overall height of 19 feet. The antenna is thoroughly weatherproofed and has a low angle DX radiation pattern. It may be ground mounted or installed on "Roof Top" with a radial system.

MODEL 12AVQ VERTICAL

The 12AVQ is a self supporting 13 1/2 foot multi-band trap vertical for 10, 15 and 20 meters. Completely factory pre-tuned with SWR of 2:1 or less with a low angle DX radiation pattern. The antenna has a new fiberglass impregnated styron base insulator. It may be ground mounted with earth acting as the "image antenna" or installed on the roof using a radial system.

DESCRIPTION

Increased activity on 80 and 40 meters has created a need for an antenna with power gain and directivity. Doublet and long wire antennas are no longer effective due to increased QRM. At these low frequencies, the radiation system must be lengthy and height above ground is extremely important to obtain the "low" angle of radiation needed for DX.

Beams are excellent, but require a large supporting tower and "hefty" rotating system. Inverted V dipoles and slopers require a large tower and plenty of property.

The vertical "phased array", the answer for "DX" on these frequencies combine gain, directivity and low angle radiation, the three most important DX factors in a communication installation. The vertical is well known for its low angle characteristics. When you combine two identical verticals, properly spaced and phased, the resultant is a concentrated low angle of energy and a power gain. These antennas can be so arranged to give a definite effect on either one or two favorite bands or all band coverage with some pattern compromise and slight loss of gain.

The following data was experimentally derived on the Telex/Hy-Gain test range. Due to the many factors that vary and influence the performance of an antenna, such as grounding and close proximity of surrounding objects, etc., Telex/Hy-Gain cannot guarantee an installation to perform or exhibit the same characteristics as outlined in this report. However, many Amateurs are now successfully using these arrangements. Commercial broadcast stations have been using a similar phasing arrangement for years.

Part 1 - SINGLE BAND OPERATION

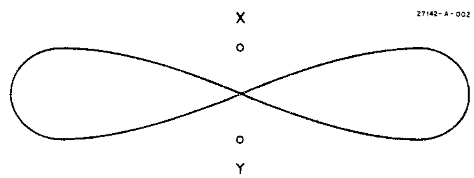
BI-DIRECTIONAL ARRAY (Four Quadrants)

THEORY OF OPERATION

Two identical vertical antennas can be installed as a phased array. When excited by RF energy, gain is achieved by control of the directional pattern. This direction pattern control results in added gain by sharpening lobe patterns and concentrating the radiated energy at very low angles. Signal flutter is reduced and reception is vastly improved.

Phased arrays will reduce installation height requirements and still maintain low angle radiation.

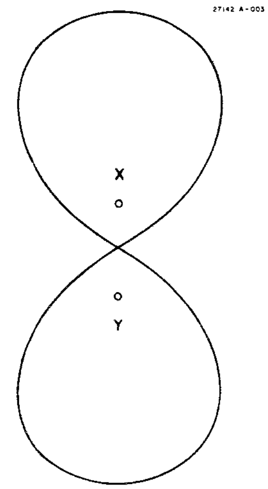
Most effective spacing for a bi-directional array is 1/2 wave length. When two verticals are excited in phase the radiation is broadside to the plane of the verticals, offering substantial gain and bi-directional characteristics. Side nulls offer excellent signal cancellation to the undesired direction.



"BROADSIDE" GAIN 3.86 dB

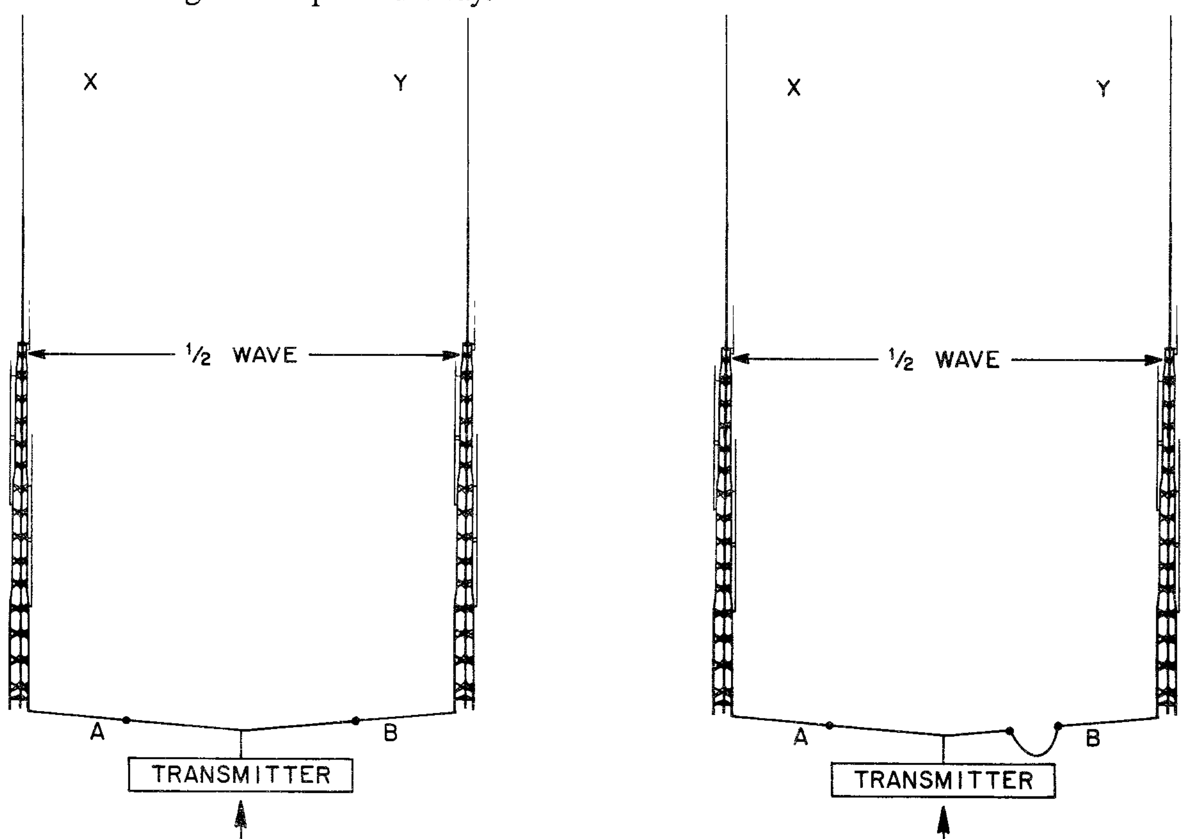
When excited "out of phase" these same verticals can be made to give an "end fire" or bi-directional pattern in the opposite direction through the plane of the verticals. This then nulls out signals in the opposite directions. More gain is exhibited by the broadside pattern over the "end fire" arrangement, but the "end fire" arrangement offers a wider frontal pattern.

Both arrangements offer an excellent advantage over a single vertical since either phasing combination exhibits noticeable signal gain with side attenuation of undesired signals. This added gain and low angle vertical directivity is the advantage of the phased array.



"ENDFIRE" GAIN 2.3 dB

Phased verticals may be spaced either one quarter wave or one half wave depending upon gain and directional characteristics. The nulls of the phased array are extremely sharp and very pronounced. Typical arrangements of phased arrays and their electrical specifications are illustrated below.



When feedline "A" is the same length as feedline "B" the currents arrive at the base of each antenna at the same time, giving the "inphase" broadside pattern.

When feedline "A" is 1/2" wave length shorter than feedline "B" the current arrives at antenna "X" 1/2 wave length sooner (180 degrees) than at antenna "Y" giving the "out of phase" end fire pattern.

Figure 1

ELECTRICAL SPECIFICATIONS

	Broadside
Pattern width, half power points	60 degrees
Gain over single vertical	3.86 dB
Side Attenuation	30 dB
Impedance	50 Ohms
Directional characteristics	Bi-Directional

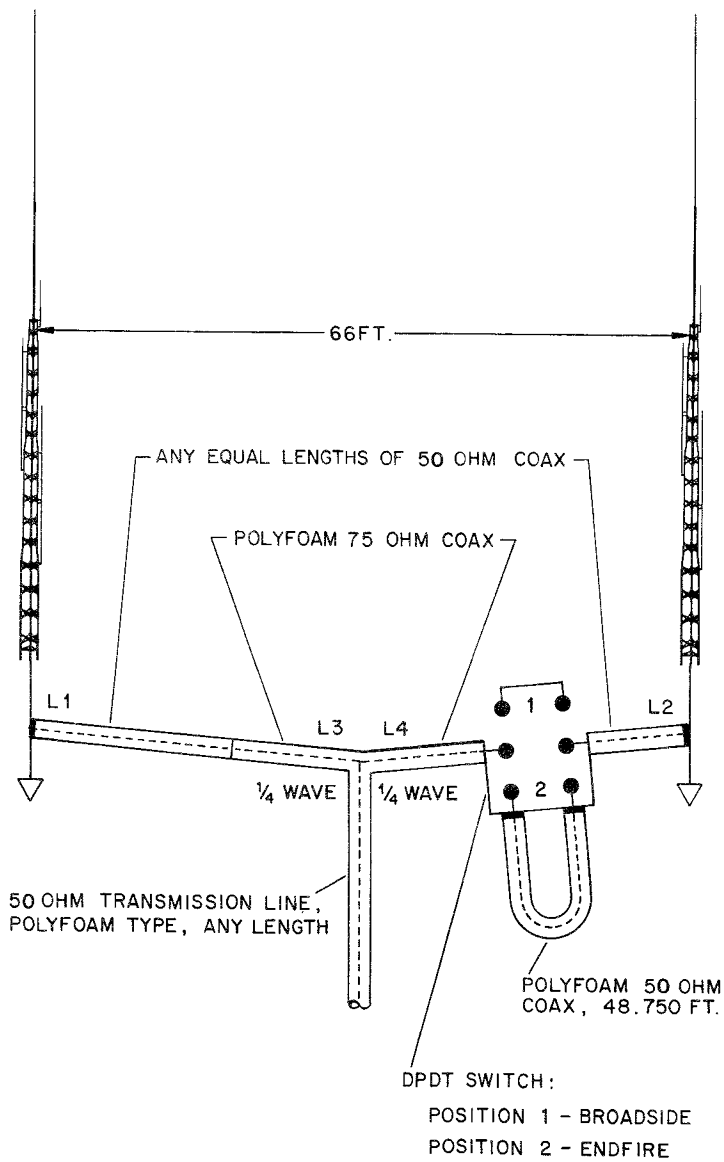
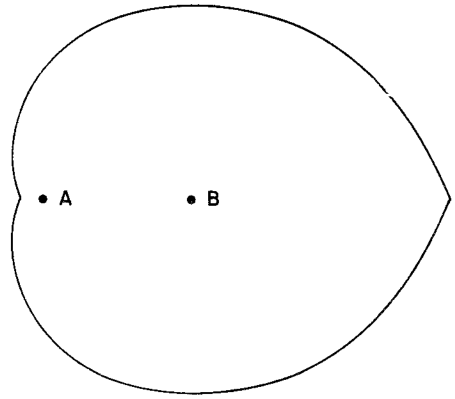


Figure 2
Typical Installation Phased (2) 18 HT 40 Meters
7200 KHz Design Frequency

CARDIOID ARRAY
(Uni-directional)

When two or three identical verticals are excited directly and fed 90 degrees out of phase with a spacing of 1/4 wave length, a cardioid pattern results. This pattern may be switched in either direction. By inserting a 1/4 wave length delay line the antenna will "fire" or be directive to that particular element.



TWO VERTICALS

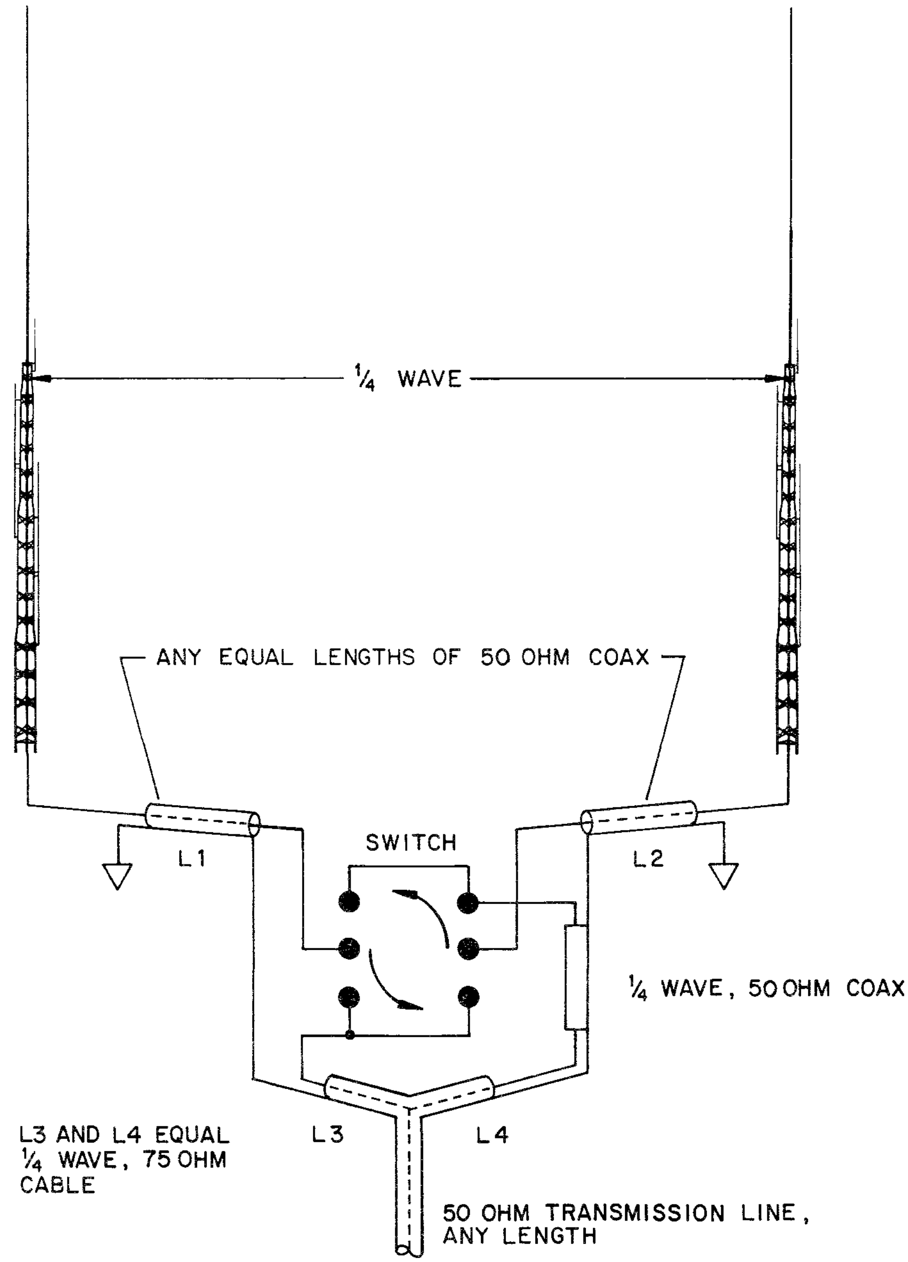
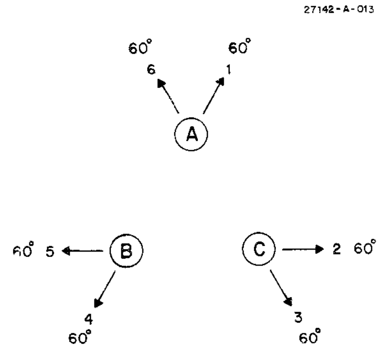


Figure 3
Cardioid-Unidirectional With Two Selectable Directions

The beam pattern for two 1/4 wave length verticals will be approximately 120 degrees. An arrangement of three switchable verticals gives a 60 degree pattern in six selectable directions.



TOP VIEW - 3 VERTICALS

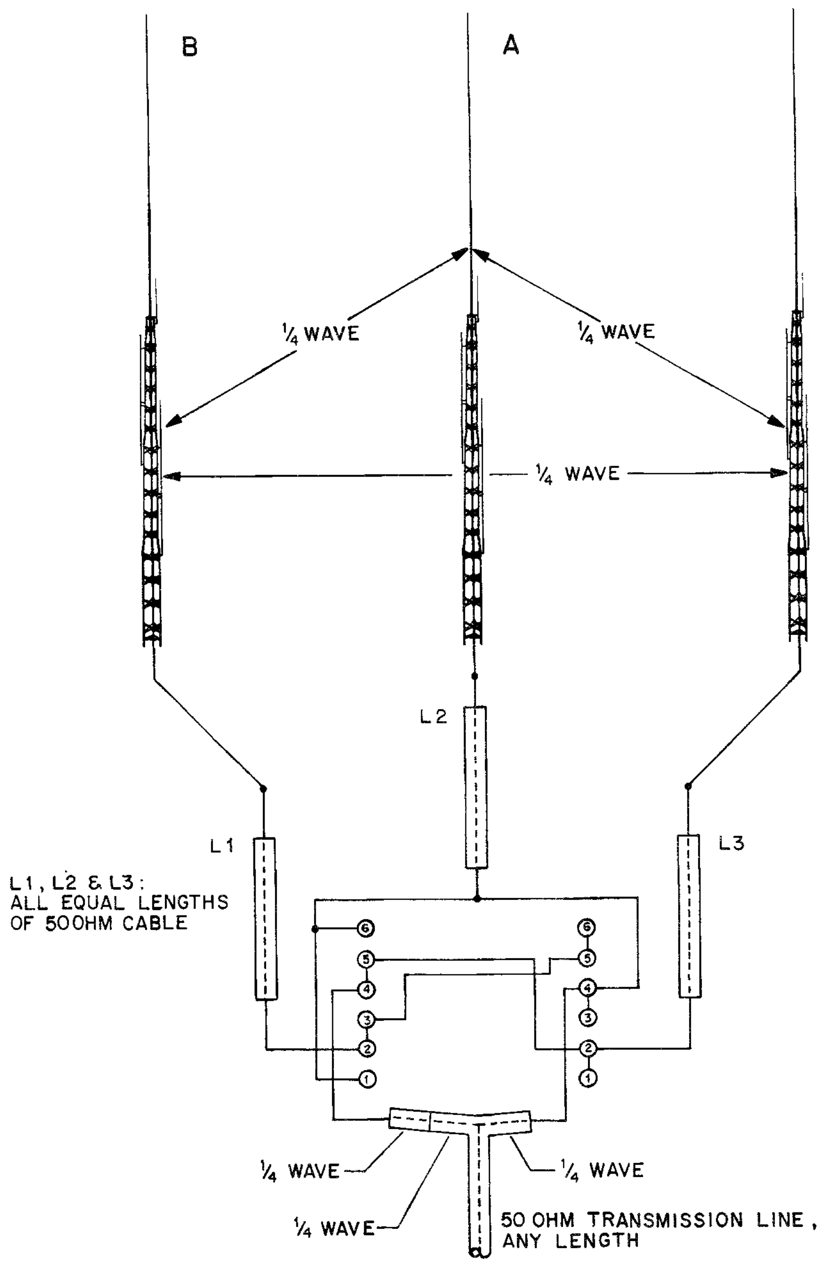


Figure 4
360 Cardioid Arrangement

ELECTRICAL SPECIFICATIONS:

	Two Phased Verticals	Three Phased Verticals
Pattern width, half power points	120 degrees	60 degrees
Gain over single vertical	4.5 dB	4.5 dB
Side attenuation	20 dB	20 dB
Rear attenuation	30 dB	30 dB
Impedance	50 Ohms	50 Ohms
Directional characteristics	Uni-directional	Uni-directional

VSWR: Exceptionally low SWR is present with a phased array. If phasing lines are correctly measured and the terminal impedance of each antenna is very close to 50 Ohms: Typical SWR: Broadside 1.2:1, Endfire 1.4:1, Cardioid 1.2:1.

PHASING LINES:

The 1/4 and 1/2 wave transformers, identified as L3, L4 and L5 are calculated from the following formula:

$$1/4 \text{ wave} = \frac{246000 \times \text{vel. factor}}{\text{frequency (in KHz)}}$$

vel. factor - reg. coax. 0.66
polyfoam 0.75

EXAMPLE:

1/4 wave at 7200 KHz = 246000 ÷ 7200 = 34.16
polyfoam line velocity factor = 0.75

$$\begin{array}{r} 34.16 \\ \times .75 \\ \hline 25.62 \end{array}$$

1/4 wave = 25.62 ft.

PART 2 - MULTI-BAND OPERATION

MULTI-BANDING

Multi-banding is easily accomplished by choice spacing two identical verticals. (refer to charts A,B, and C and associated Figures 1 through 5) Switchable 1/4 wave length and 1/2 wave length phasing cables must be employed for each band. These cables can be placed in the station in any suitable fashion along with a manual switching arrangement or relay system.

RADIATION PATTERN:

Consideration must be given to the fact that 1/2 wave spacing (optional) is ideal for phasing. When multi-banding with close and wide spacing, compromise radiation patterns must be expected. In most cases a choice spacing serves 3 bands most effectively with good directional characteristics, added gain and low angle performance.

OPTIONAL SPACING

Various antenna spacings may be selected from charts A, B, and C, for single band, duo band or multi-band arrangements. Associated radiations patterns for a specific spacing is shown in Figures 1 through 5 for each band.

If the 3/4 wave length patterns are not desirable, a single vertical only can be switched in use to obtain an omni-directional pattern.

INSTALLATION

The vertical antenna requires a minimum amount of space. Ground mounted or elevated arrays are easily installed.

Antenna placement and orientation is a most important factor when planning maximum effectiveness is desired directions. Each vertical should be installed in the clear relatively free of surrounding objects in order to maintain its design 50 Ohm terminal impedance.

Each antenna must be mounted at the same height on or above ground and be so arranged according to their radiation pattern to offer desired directivity.

The phased array is primarily designed for long range and DX communications. In cases where close and medium distance contacts are hampered by the array's low angle characteristics and a higher angle is required, switching arrangements can select one vertical for this coverage.

SWITCHES & CONNETORS

Low loss constant impedance type coaxial switches and connectors should be used when splicing phasing lines. B&W multi-position, single or multi-gang coaxial switches with Amphenol coaxial cable and "T" connectors are recommended.

FIELD TESTS

Actual field tests comparing one vertical to the phased array results in doubling the receivers sensitivity and offering up to 12 dB of signal increase. An attenuation of up to 30 dB is noticeable on the phased verticals with half wave spacing. With quarter wave spacing, up to 20 dB cardioid, and 30 dB front-to-back attenuation can be obtained.

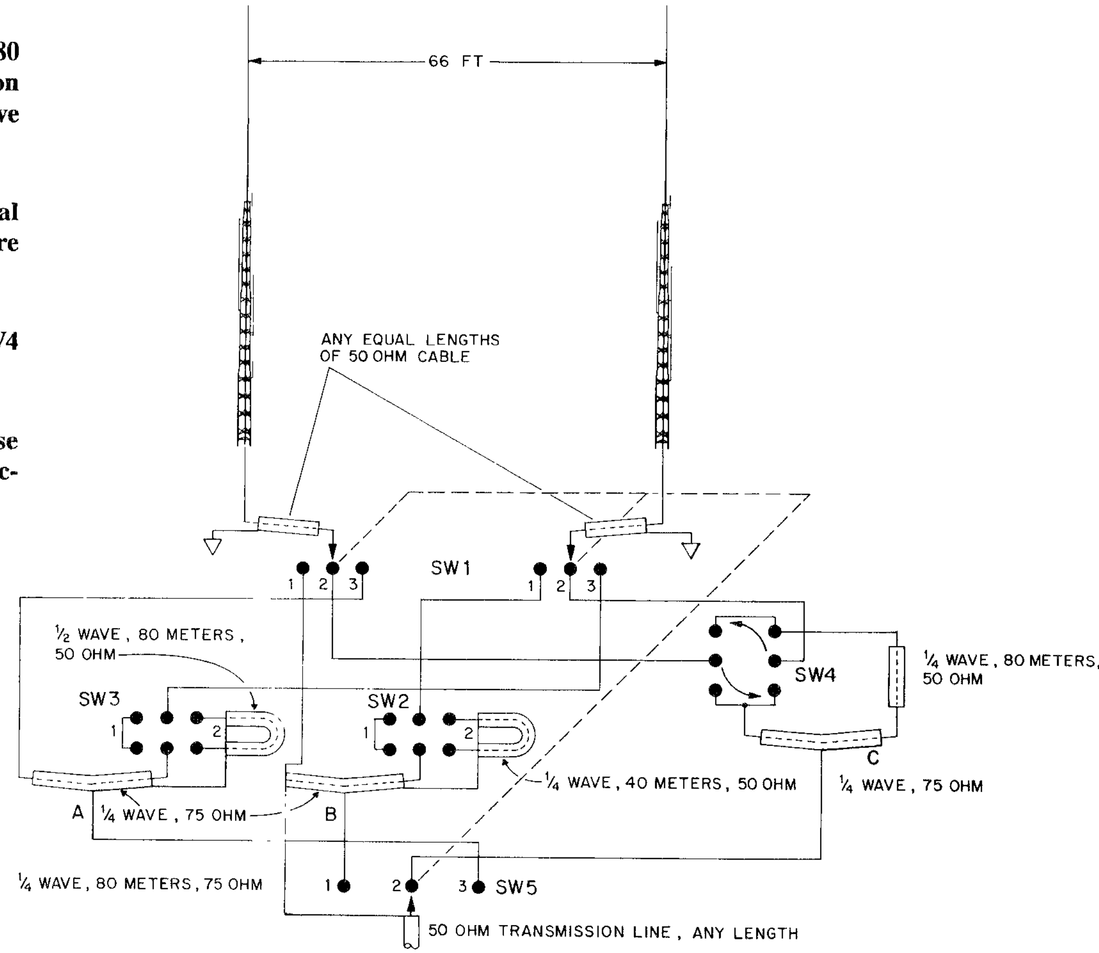
"End Fire" directivity offers a larger area of radiation at slightly reduced gain as compared to the broadside arrangement. The "broadside" arrangement is recommended for communications at greater distances whereas the "endfire" arrangement would be so arranged to cover a larger area of communications. Special attention to the coax phasing line lengths and their proper placement is of utmost importance.

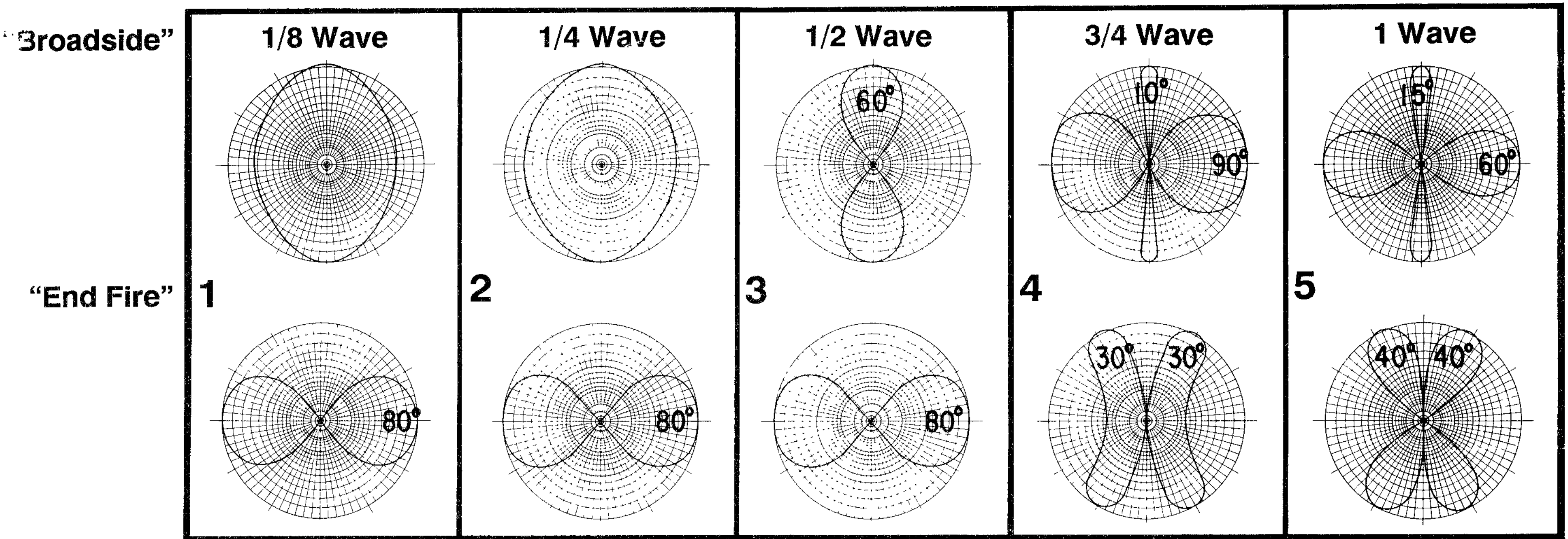
NOTE: Due to close electrical spacing (1/4 wave) on 80 meters for Broadside (position 1) and Endfire (position 2) the SWR may be somewhat higher than 1/2 wave spacing. SW3 selects direction

B. 40 meters all switches in position 1 selects Bi-Directional patterns. Use SW2 for broadside (position 1) Endfire (position 2).

C. All switches in position 2 selects cardioid pattern. SW4 selects direction of cardioid pattern.

NOTE: All connecting lines are exaggerated in length. These lines must be direct and short as with any coax hook-up practice.





PATTERN CHART

Spacing		1	2	3	4	5
		Single Band Arrangement				
A	125'			80		
	66'			40		
	33'			20		
		Dou Band Arrangement				
B	66'		80	40		
	33'		40	20		
	16'		15	10		
		Multi-band Arrangement				
C	33'	80	40	20	15	10
	66'		80	40	20	

Note: Corralate Patterns to spacing used in installation

TELEX® hy-gain®

TELEX COMMUNICATIONS, INC.

PN 801774-1

Made in U.S.A.